



Largest U.S. municipal utility emphasizes online systems in long-term maintenance strategy



by Brian A. White, P.E.

*Generation Maintenance Mechanical Engineering Associate
Power Operating and Maintenance Division — CBM Task Force Chairman
Department of Water and Power
City of Los Angeles*



and Sid Walkman

*Station Mechanical Engineering Associate — CBM Task Force Chairman
Haynes Generating Station*

and Joseph Weidman

*Sr. Sales Engineer
Bently Nevada Corporation*

Los Angeles Department of Water and Power's (LADWP) Haynes Generating Station uses Trendmaster® 2000 as a platform for a successful Condition Based Maintenance (CBM) Program



Haynes Generating Station, Long Beach, California. Photo courtesy of Department of Water and Power, City of Los Angeles.

Los Angeles Department of Water and Power (LADWP) is the largest municipal utility in the United States. The LADWP provides water and electricity to more than 3.5 million residents within the boundaries of the City of Los Angeles. The LADWP has approximately 1.3 million electrical customers and a local generating capacity of 4,300 megawatts. Additional capacity is obtained via long-term energy contracts. Energy sources include fuel oil, natural gas, coal, hydro and nuclear. The Haynes Generating Station, located in Long Beach, California, is the largest of LADWP's four fossil fuel plants, with six turbine generators producing 1600 megawatts of electricity. LADWP-Haynes has had a long history of success using Bently Nevada products. LADWP currently uses, or has used, Bently Nevada 3300 and 7200 Monitoring Systems, the ADRE® for Windows and ADRE 3 Systems, 108 Data Acquisition Instrument, Digital Vector Filter 3, Digital Vector Filter 2, Trendmaster 2000 and Snapshot. For

continuous protection, all six of Haynes' turbine generator sets are monitored by either Bently Nevada 3300 or 7200 Monitoring Systems.

History of data collection and analysis at Haynes

In the mid to late 1980s, LADWP's General Services group, in downtown Los Angeles, ran a centralized data collection and analysis service for all LADWP generating stations. This program used portable instruments. Whenever the operators at Haynes suspected a machinery problem, the Engineering Section of General Services (now called Generation Maintenance) was asked to investigate. At Haynes, LADWP didn't have the people, expertise or equipment necessary to collect and analyze vibration data. Depending on the personnel available at General Services, it would sometimes take days before a machinery analyst arrived. Unfortunately, when an analyst would arrive, there was little or no historical machine operating data available to him. ▶

In 1989, LADWP management decided that each plant would become responsible for its own data collection and analysis program. At first, this was more of a time-based than a condition-based program. Records were kept, but somewhat haphazardly. Regularly scheduled maintenance was being performed, rather than proactively determining the maintenance that would be required at the next scheduled outage. Weekly vibration measurements were taken on most machines using a portable instrument. **However, it was soon realized that weekly measurements provided too little data to make timely operating and maintenance decisions.** And often, due to staffing constraints, these readings were only taken once per month.

In 1990, LADWP's Condition-Based Maintenance (CBM) Task Force began investigating online systems. Online monitoring promised to be more cost-effective than manual data collection and would provide more timely information. Timely information enhances LADWP's ability to make better recommendations to management concerning the operation and maintenance of the machinery. Besides, taking readings by hand can be uncomfortable and unsafe in certain areas, for example, the inside of a turbine housing at 52°C (125°F).

LADWP's Condition Based Maintenance (CBM) Task Force

LADWP's CBM Task Force began as a group of Haynes personnel directed by the plant's superintendent to develop a CBM handbook. LADWP recognized the group's value and expanded it to include a representative from each plant. The CBM Task Force now meets every six to eight weeks to discuss what is currently being done, what should be done, what is working and what is not working. The group discusses technical details and makes sure that everyone is on the same path. LADWP wants each station to have its own CBM program, while avoiding duplicate research and effort. LADWP management's main goals for the Condition-Based Maintenance program are:

- 1. To reduce the unscheduled maintenance of critical equipment through the use of**

predictive and preventive maintenance diagnostic techniques and trending.

- 2. To increase the intervals between maintenance for critical equipment, which in turn reduces the maintenance and capital expenditures for each generating station.**

One of the CBM Task Force's main missions is to keep informed of, and investigate, new technology and ways in which LADWP may apply it to increase efficiency or reduce costs. One method used is to invite suppliers to make a presentation at a Task Force meeting. This enables the Task Force to compare and contrast suppliers' products, knowledge and support. This is how the CBM Task Force learned of Bently Nevada's Trendmaster 2000 System.

The CBM Task Force researched online monitoring systems in 1990-91. LADWP wanted to evaluate the effectiveness of this type of monitoring system, so the CBM Task Force recommended that Haynes purchase and install one on a trial



Brian White checks on Trendmaster 2000 TIM housings, mounted near the machine.

“... it has also been previously deferred, LADWP would easily LADWP did not have to

basis. Through a competitive evaluation and bid process, Bently Nevada's Trendmaster 2000 was chosen as the system that provided the most benefit at the lowest cost. Operators at other LADWP plants were to view the information provided by this test system, either onsite at Haynes or remotely, and evaluate the system's benefits. LADWP's Scattergood Generating Station purchased a second Trendmaster 2000 System in 1993.

LADWP's experience with Bently Nevada has been good, and that's why LADWP uses many Bently Nevada products. LADWP appreciates the way Bently Nevada products integrate with each other. Also, Bently Nevada's Design and Installation Services (D&IS) and Product Service personnel have given LADWP exceptional technical support during system installations and expansions. Many of LADWP's personnel have attended a variety of Bently Nevada Technical Training Courses to increase their knowledge in data acquisition and machinery diagnostics.

Trendmaster 2000 at Haynes Station

At Haynes Station, LADWP uses the Trendmaster 2000 as a trending and diagnostic tool to detect possible problems on the turbine generators and auxiliary equipment. Because the Trendmaster 2000 performs periodic monitoring, it is likened to “taking the pulse” of the equipment. Bently Nevada 3300 and 7200 Monitoring Systems provide machinery protection on the turbine generators; the Trendmaster 2000 provides machinery information, trending and first level diagnostics. Alarm limits on the continuous monitors are set to the “maximum allowable” level, while the redundant software alarms on Trendmaster 2000 are set at a lower level. That way the Trendmaster 2000 alarm will typically be exceeded first,

*calculated that if just one outage were
save twice the original investment.
wait long for this payback.”*

providing an “early warning” signal of a possible machine problem, before its corresponding 3300 or 7200 Monitor relay actuates. If the Trendmaster 2000 indicates a potential problem on a turbine generator, a portable ADRE System with a Data Acquisition Instrument is used to investigate the problem further. The Trendmaster 2000 System is LADWP’s “early warning” indicator, and the ADRE System an advanced diagnostic tool.

The Trendmaster 2000 also provides LADWP with important historical information on their machines. This long-term trending is something that was not available in the past. It is invaluable information for LADWP’s planning of machinery maintenance.

Another reason the Trendmaster 2000 System was chosen is its Remote Access feature. To give operators 24-hour access to its data, the Trendmaster 2000 host computer is located in Haynes’ control room. With a PC, modem and telephone line, LADWP engineers and machinery specialists can remotely access Haynes Station data anywhere, anytime. The system is typically accessed from across the plant and from downtown Los Angeles each morning and checked for any conditions that may have occurred overnight.

Long-term investment

It took LADWP approximately one month to complete the installation of the initial 200-point Trendmaster 2000 System at Haynes. LADWP contracted with Bently Nevada’s Design and Installation Services group to provide site supervision, system checkout and system documentation. LADWP personnel installed the transducers, cabling and field hardware. Trendmaster 2000 system cable was installed in existing cable trays, rather than in conduit, to minimize installation cost.

This 5-year project began in 1992-93 with Phase 1. In that phase, existing continuous monitoring racks on the turbine generators were interfaced to the Trendmaster 2000. In 1993-94 under Phase 2, critical auxiliaries, such as boiler feed pumps and Induced Draft/Forced Draft fans, were connected to the system. LADWP’s goal is to put the most important machines online first.

LADWP calculated that installing a proximity transducer, a Displacement Transducer Interface Module (TIM) and cabling on a major auxiliary has cost approximately \$1500 per point, including labor and materials. On each major auxiliary, an XY proximity probe pair is installed on each bearing along with a single Keyphasor® probe for the machine.

It has been calculated that LADWP will invest approximately \$1.2 million to design, purchase and install the entire Haynes Generating Station vibration monitoring system over the 5-year project. However, it has also been previously calculated that if just one outage were deferred, LADWP would easily save

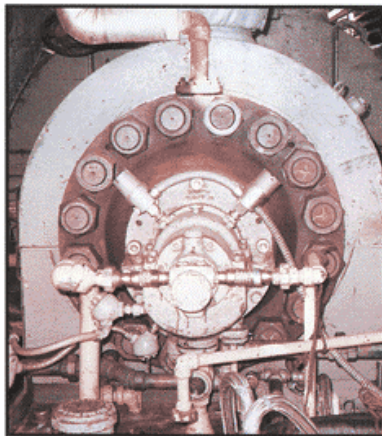
twice the original investment. LADWP did not have to wait long for this payback.

Short-term payback

Previously, LADWP scheduled major machine outages based on time of service (the number of generating hours), and these averaged once every four to six years. At times, upon opening a machine for overhaul, it was found that the machine did not need repairs extensive enough to warrant disassembling the machine. Also, sometimes machinery would return after being repaired by an outside vendor and would not meet repair specifications. This all added up to higher maintenance costs for LADWP.

Deferring an outage can save a utility millions of dollars. LADWP is depending on the Trendmaster 2000 system and the Conditioned Based Maintenance program to lengthen the period between major overhauls. LADWP has estimated that in a 12 year maintenance cycle, approximately \$2.5 million dollars per year will be saved through deferred outages using CBM. A typical unplanned outage can cost LADWP about \$10 million dollars in lost revenue and added repair costs. This costs far more than a long-term energy contract that might be purchased in advance for a planned outage. LADWP credits the Trendmaster 2000 with helping to defer two outages since its installation in 1993.

One example is Haynes’ Unit Four. In the summer of 1993, its number two bearing showed high vibration. It is a shared bearing, with an HP rotor and an IP, and an IP with an LP. One bearing supports the whole load on two turbine shafts, two sections of blades, and it has a built-in thrust bearing. It’s a complicated, very large bearing. It was discovered that at different loads, the bearing becomes loaded or unloaded. The Trendmaster 2000, the ADRE 3 System and load testing helped LADWP to identify this as a possible alignment problem. The bearing rests at a little bit of a slope, so at different axial loads, the turbine will sit at different axial positions. The bearing will shift one way and become loaded, then shift the other way and become unloaded. ►



**Bently Nevada XY
proximity probe installation.**

“LADWP credits the Trendmaster 2000 with helping to defer two outages since its installation in 1993.”

When unloaded, its degree of freedom increases and likewise its vibration, up to 230 μm (9 mils), which can be very harmful for a turbine of that size. LADWP tracked online data with the Trendmaster 2000 and realized that, at a load of about 190 megawatts, the vibration damped down to 100 μm (4 mils). From 190MW to 205MW, the vibration would increase again. From 205MW to about 230MW, it would decrease. It was recommended that the unit be taken out of service and aligned. However, because of summer power demands, LADWP management decided to continue running the unit at a load identified with low vibration levels using Trendmaster 2000 data. By identifying acceptable operating parameters, data from Trendmaster 2000 helped LADWP extend the unit's run time.

LADWP's CBM Task Force documented this payback and reported it to management in its yearly report. The report informed management of the program's status, goals that were achieved, and also summarized success stories. A bimonthly status report is also generated for the Station Superintendent that details current machine status, problems identified (with supporting documentation) and recommendations. In just its first months of operation, the Trendmaster 2000 has been credited by LADWP with helping to save money equal to the amount that was spent to date on the Haynes CBM program, through deferred outages, early problem identification and avoided maintenance.

LADWP has also benefitted from using the Trendmaster 2000's Remote Access Software. A trip from the Power Operating and Maintenance Division office in downtown Los Angeles to Haynes Sta-

tion takes about 40 minutes. With Trendmaster 2000, Generation Maintenance personnel no longer have to leave downtown L.A. to access and analyze data, print out plots and generate reports on the condition of the machines at Haynes. The Trendmaster 2000's Remote Access feature results in minimized driving time, which in turn saves time and money. The Remote Access feature is also used to obtain quick verifications and recommendations from Bently Nevada Machinery Diagnostics Services (MDS) Engineers and Product Service representatives. Assistance can be requested from the local Bently Nevada office or corporate headquarters, and Bently Nevada personnel can then access Haynes' system directly via modem without having to travel to the site.

Success, credibility and long-term vision

LADWP's CBM program is continuously gaining credibility with management. Haynes station management now relies on CBM reports and trusts the recommendations they make. History has shown that CBM team recommendations prove themselves correct. More often than not, when a machine rub is predicted and the machine is opened up, clear evidence is found to support it. With these successes, management can rightfully have confidence in the team's recommendations.

Since Southern California's economy is currently very sluggish, LADWP management is counting on the CBM program to save the utility money through reduced operation and maintenance costs. By supplying important current and historical condition information on

LADWP machinery, Trendmaster 2000 has become a big part of the CBM program. The information it provides helps LADWP to determine which machines need service, and the maintenance they require, during an outage. This enables LADWP to plan ahead for a faster, more efficient turnaround.

LADWP's long term plan is to interface all main auxiliaries to the Trendmaster 2000. When installing the initial system, long-term monitoring needs were considered and planned for. In the first phase, all the main cabling and cable T-Connectors required for future expansions were also installed. This will minimize future expansion costs, since cabling costs tend typically to be the highest installation cost factor. LADWP appreciates Trendmaster 2000's flexibility. With the main cabling already in, expansion to more machines requires only the installation of additional transducers, TIMs and housings.

LADWP management anticipates that the Trendmaster 2000 System will help it meet future maintenance challenges. A large challenge is determining the most effective time for machine maintenance: not before and certainly no later than required. To be successful in the long term, LADWP must become more cost-efficient. Trendmaster 2000 is one of the investments made by LADWP to help meet the utility's long-term goals. LADWP has used "benchmarking" studies to compare LADWP plants with each other and with other utilities, to determine best management, maintenance and operations practices. LADWP's goal is to learn which practices will help them succeed. LADWP is taking a proactive approach to developing and optimizing future maintenance strategies. ■